

heating current for heating the tube. Egan's atomizer circuit is basically an analog circuit and each major element is controlled by analog signals. The circuits being digitally controlled according to this invention are clearly disclosed in the specification and hence there arises no problem of any new matter being introduced. It is well settled that rejection of a claim under 35 U.S.C. 102 is justified only when each of the inventive elements in that claim is disclosed in one reference. Egan does not disclose every inventive element in amended independent claim 1, and hence it is believed that the Examiner's rejection of claim 1 and the claims dependent therefrom is not justified and hence should be reversed.

Secondly, the parameter setting means is now said to set the parameters according to conditions of measurement (such as the minimum detectable quantity) such that the response characteristic of the heating control (more narrowly limited in claims 2 and 17 as "indicial response of a PID control" of the heating) can be adjusted (page 10, lines 17-21). Egan's atomizer can be adjusted stepwise in a fixed manner according to the stage of processing such as the drying stage and the atomization stage process but cannot be freely adjusted according to the measurement condition. Egan simply discloses a general concept of the PID control but does not even mention the PID control. In other words, it is not a mere matter of whether the control is analog or digital that differentiates the present invention from Egan. It is believed for this reason that neither can Egan predicate the Examiner's rejection even on the ground of obviousness under 35 U.S.C. 103.

Claim 2 has been amended only for stressing that the calculator operates digitally. This is also supported by the specification (page 8, lines 22-24) and hence no new matter is thereby being introduced. It is easily ascertainable that Egan does not disclose a digital calculator receiving signals from an A/D converter.

The aforementioned parameter setting means may serve to set parameters not only according to measurement conditions as described above but also according to the type of the elements (page 4, line 26 to page 5, line 5). New claims 12-16 with this limitation have been introduced. Since Egan's atomizer cannot be used to freely adjust operating parameters

according to the type of the elements for detection, these new claims are also believed to be allowable.

For the rejection of dependent claims under 35 U.S.C. 103, the Examiner additionally considered secondary references by Schmider, Pettit and Clishem. As correctly admitted by the Examiner, Schmider does not disclose any control mode over the heating mechanism. Pettit generally relates to the PID control and a method of determining constants (such as the derivative time constant) used in the control. The PID control, however, can be applied in a great number of different ways. In fact, Pettit itself teaches that each implementation of a PID algorithm behaves in a different manner (column 2, lines 41-48). In other words, Pettit itself is teaching that the method of applying the PID as taught by Pettit may not be directly applied in other situations such as the control of a heating system for a furnace-type atomic absorption spectrophotometer. The Examiner has a heavy burden of proving that a person of an ordinary skill would have easily come up with the kind of control according to the present invention merely on the basis of Egan and Schmider plus the teaching of Pettit that includes the aforementioned warning.

As for Clishem, this reference relates to an electrical furnace but does not disclose the PID control. Accordingly, Clishem is totally silent regarding the adjustment of any PID control for the specific purpose of heating control according to the measurement condition or the type of elements to be detected in spectrophotometry. Again, therefore, it is believed that the Examiner has a heavy burden of proving that a person of an ordinary skill would have found it obvious to adjustingly set parameters in a PID control specifically according to measurement conditions for or the type of elements to be detected in spectrophotometry by means of a furnace-type atomic absorption spectrophotometer. Applicant believes that the Examiner cannot, in view of the amendment effected herein.

Editorial errors discovered while the specification was being reviewed are also corrected herein. It is therefore believed that this Amendment is completely responsive to the Office Action and hence that the application is now in condition for allowance.

Attached hereto is a marked-up version of the changes made to the specification and

claims by the current amendment. The attached page is captioned "Version with markings to show changes made."

Respectfully submitted,



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January 22, 2003
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VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE SPECIFICATION:

Paragraph starting at line 21 of page 1 has been amended as follows:

Fig. 5 shows an example of a general temperature program set for a prior art atomic absorption spectrophotometer. Fig. 6 is a graph for showing the temperature variation according to the temperature program thus set. The example of the temperature program shown in Fig. 5 may be characterized as dividing the time into a plurality (six in the example shown) of stages and setting for each of these stages the final temperature to be reached, the time which will elapse until this final temperature is reached and the heating mode related to the temperature change. In the column for the heating mode in Fig. 5, "~~ramp~~" "ramp" means a mode in which the temperature is to increase uniformly, or linearly at a constant rate with respect to time and "step" means a mode in which the temperature increases suddenly in a stepwise fashion.

Paragraph starting at line 22 of page 3 has been amended as follows:

As explained above, prior art spectrophotometers were designed to increase the temperature as rapidly as possible so as to shorten the time required to reach the target temperature without regard to the response characteristic such as the indicial response characteristic corresponding to the step response characteristic as the temperature is increased in a stepwise fashion. A furnace-type atomic absorption spectrophotometer according to this invention, by contrast, is characterized wherein its temperature response characteristic is made variable as the increase in the temperature of the heating tube is controlled. As a result, the rise in the temperature can be controlled according to this invention by providing an optimum response characteristic, depending on the kind of the target element to be detected as well as

other conditions of the measurement, such that the minimum detectable quantity can be made as small as possible. The response characteristic according to this invention is determined in units of milliseconds, unlike the prior art ~~"rump"~~ "ramp" mode of temperature control which takes place in units of seconds.

Paragraph starting at line 6 of page 4 has been amended as follows:

A furnace-type atomic absorption spectrophotometer embodying this invention, with which the above and other objects can be accomplished, may be characterized as comprising a tube for heating a sample therein, monitoring means for monitoring temperature of the tube or a value indicative thereof and outputting a monitored temperature or the value indicative thereof, heating control means for controlling an electrical heating current for heating the tube such that the monitored temperature or the value indicative thereof will approach a specified target temperature value, and parameter setting means for setting parameters which determine a response characteristic of the heating control means when the tube is heated by the heating control means. The monitoring means may be an optical detector for detecting the light emitted from the tube and in such a case the value indicative of the temperature may be the intensity of the emitted light. The heating control means serves to keep updating the target temperature value or another variable value indicative of the target temperature by a predetermined temperature program and controls the heating current to the tube such that the monitored value obtained by the monitoring means will become or approach this target temperature or the value indicative thereof. Generally speaking, the heating current is increased if the difference between the target temperature and the monitored temperature is large and it is decreased if the difference is small. The response characteristic associated with this control is variable according to the parameters which are set by the parameter setting means. In typical examples, these parameters are appropriately adjusted according to the kind of target element being analyzed. The magnitude of absorbance depends differently on the speed at which temperature is raised,

depending on the type of the ~~element~~, elements. In the case of an element of which absorbance depends only weakly on the rate of temperature increase, parameters are selected such that the obtained response characteristic will be such that the speed in the temperature change will not become too large because the absorbance of such an element will become saturated or its increase will be extremely small when the rate of temperature increase is made greater than a certain level. If various modifiers have been added to the sample, the parameters should be changed appropriately by taking into consideration the characteristics of these added agents.

Paragraph starting at line 27 of page 5 has been amended as follows:

The heating control means according to this invention may be adapted to carry out a PID control calculation on the difference between the monitored and target values to obtain a quantity of specified operation. Since the quantity of the specified operation is determined by this control method from the proportional (P), integration (I) and differential (D) operations based on the difference between the monitored and target values, proportional, integration and differential elements serve as the aforementioned control parameters. If the electric current for the heating is switched on and off by a phase control method, the firing angle for the phase control may be the aforementioned quantity of a specified operation.

Paragraph starting at line 18 of page 8 has been amended as follows:

Next, the operations for the temperature control of the graphite tube 3 are explained. At the beginning of a measurement, the user inputs through the keyboard 25 a temperature program such as shown in Fig. 5. The inputted temperature program is then stored in the temperature setting means 24 which already stores a target value for the optical sensor 16- corresponding to the temperature. As the graphite tube 3 is heated, the output from the optical sensor 16

corresponding to the measured temperature is inputted as a digital signal into the calculator 21 by going through the A/D ~~converter~~ converter 18. At the same time, a target value for the optical sensor 16 corresponding to the set temperature at the present time is provided from the temperature setting means 24 to the calculator 21. The calculator 21 operates to calculate the difference between the current output value from the optical sensor 16 and the target value and calculates the firing angle α by using a calculation algorithm for the PID control on the basis of this difference value. The pulse generator 19 thereupon produces a pulse signal corresponding to this firing angle α and carries out the on/off control of the semiconductor switch 11.

Paragraph starting at line 3 of page 9 has been amended as follows:

For carrying out the aforementioned PID control, it is necessary to provide so-called PID control parameters including the proportional parameter P, integration parameter I and differential parameter D. If these parameters are changed, the temperature response characteristic will change at the time of rise in the temperature. Let us consider an example of control wherein the outputs from the optical sensor 16 are monitored at a sampling period of T_s and the outputted values are controlled so as to become stabilized at a value corresponding to the target temperature by appropriately adjusting the firing angle α which determines the power for the heating the tube 3 according to these monitored values. Let E_k be the error obtained by subtracting the monitored value from the target value at the time of the kth sampling (k being a dummy index). Then, the firing angle α_k is given by the following formula:

$$\alpha_k = K_p \{ E_k + (T_s/T_i) \sum_{j=0}^k E_j + (T_d/T_s)(E_k - E_{k-1}) \}$$

where K_p , T_i and T_d are PID control parameters to be set, being respectively referred to as the proportional gain, the integration time and the differentiation time.

Paragraph starting at line 16 of page 12 has been amended as follows:

Although the invention has been described above with reference to only one example, but this example is not intended to limit the scope of the invention. Many modifications and variations are possible within the scope of the invention. For example, although it was shown that the PID control parameters are to be inputted by the user, control parameters which will minimize the minimum detectable quantity under several different conditions of measurement may be preliminarily stored such that the user has only to input conditions of measurement from the keyboard 25 such that appropriate control parameters are automatically selected and inputted to the calculator 21.

Paragraph starting at line 24 of page 12 has been amended as follows:

The control unit 20 may be also designed so that PID control parameters will be automatically set so as to minimize the minimum detectable quantity or make it approach such a minimum value under a given condition. Explained more in detail, this may be done when a measurement is to be made on a certain sample under a certain condition by repeating measurements with a set of PID control parameters while varying them and thereby obtaining an average absorbance value and its standard variation and finding PID control parameters that will minimize their ratio. Such PID control parameters thus determined for different conditions of measurement may be stored in a memory such that, when a condition is specified, PID control parameters corresponding to the specified condition can be retrieved from the memory.

IN THE CLAIMS:

Claims 1-7 have been amended as follows:

1. (Amended) A furnace-type atomic absorption spectrophotometer comprising:

a tube for heating a sample therein;

monitoring means for monitoring temperature of said tube and outputting a monitored value indicative of the monitored temperature;

heating control means for digitally controlling heating current for heating said tube such that said monitored value will approach a specified target temperature value; and

parameter setting means for setting parameters ~~which determine~~ according to conditions of measurement and thereby adjusting a response characteristic of said heating control means when said tube is heated by said heating control means.

2. (Amended) The spectrophotometer of claim 1 wherein said heating control means includes a calculator for digitally obtaining a quantity of a specified operation of said heating control means by a PID control calculation on difference between said monitored value and said target temperature value and said parameter setting means serves to set at least one of parameters for said PID control calculation.

3. (Amended) The spectrophotometer of claim 1 wherein said parameter setting means includes an input device for allowing a user to input therethrough said parameters.

4. (Amended) The spectrophotometer of claim 1 wherein said parameter setting means ~~include~~ includes an input device for allowing a user to input therethrough a condition corresponding to said parameters.

5. (Amended) The spectrophotometer of claim 2 wherein said parameter setting means ~~include~~ includes an input device for allowing a user to input therethrough said parameters.

6. (Amended) The spectrophotometer of claim 2 wherein said parameter setting means ~~include~~ includes an input device for allowing a user to input therethrough a condition corresponding to said parameters.

7. (Amended) The spectrophotometer of claim 2 wherein said PID control is carried out with a ~~parallel~~ proportional parameter, an integration parameter and a differential parameter.